

1-19-2018

Exploring the Determinants of Vulnerable Road Users' Crash Severity in State Roads

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Caviedes, Álvaro, "Exploring the Determinants of Vulnerable Road Users' Crash Severity in State Roads" (2018). *TREC Friday Seminar Series*. 137.

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DETERMINANTS OF VULNERABLE ROAD USERS' CRASH SEVERITY IN STATE ROADS

Álvaro Caviedes
Miguel Figliozi

TABLE OF CONTENTS

- 1. BACKGROUND**
- 2. PROBLEM STATEMENT**
- 3. DATA AND METHODS**
- 4. RESULTS**
- 5. CONCLUSIONS**

BACKGROUND

1. Department of Transportation's (DOT) interest in increasing non-motorized transportation

BACKGROUND

1. Focus on driver safety
2. Crash frequency vs crash severity

BACKGROUND

1. Urban environments

2. Risk factors:

- Location,
- Environmental,
- Crash,
- Road,
- Demographic, and
- Traffic characteristics.

PROBLEM STATEMENT

Explore risk factors of crash severity for pedestrians and bicyclists in the Oregon Highway Network System

DATA AND METHODS

1. Oregon statewide crash database (2007-2014)
2. ODOT's TransGIS database
3. Neighborhood concepts (Currans et al. 2015)

INJURY SEVERITY LEVELS

K (FATAL) - **KILLED**

A (INCAPACITATED)- **ALMOST KILLED**

B (VISIBLE INJURY) – **BRUISE**

C – **COMPLAIN OF PAIN**

O – **ONLY PROPERTY DAMAGE**

CRASHES IN THE OREGON HIGHWAY STATE NETWORK

VARIABLE	PEDESTRIAN CRASHES IN OREGON	ONLY STATE HIGHWAYS	BICYCLIST CRASHES IN OREGON	ONLY STATE HIGHWAYS
TOTAL CRASHES	6,162	1,840 (30%)	7,147	1,584 (22%)
CRASHES AT INTERSECTIONS	3,629	1,088	4,702	1,045
CRASHES AT SEGMENTS	1,822	561	864	169
OTHERS	711	191	1481	370

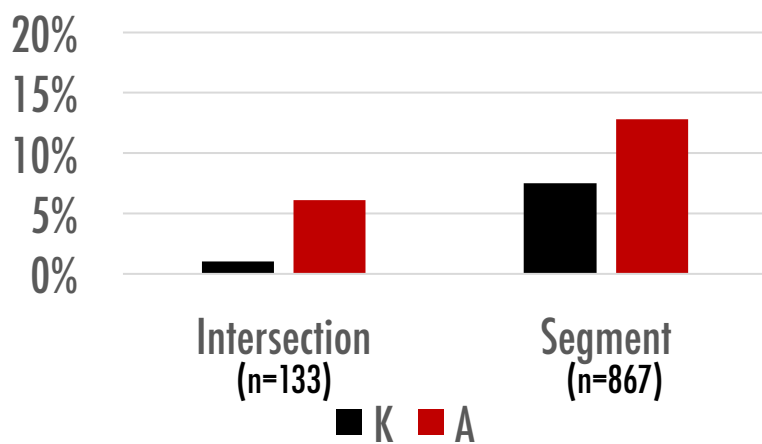
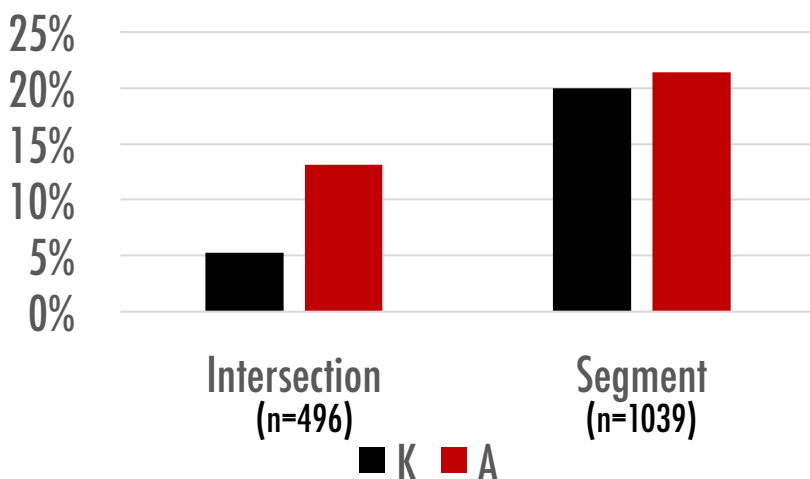
DESCRIPTIVE ANALYSIS

- 1. Location characteristics**
- 2. Environmental conditions**
- 3. Crash characteristics**
- 4. Traffic characteristics**
- 5. Road characteristics**

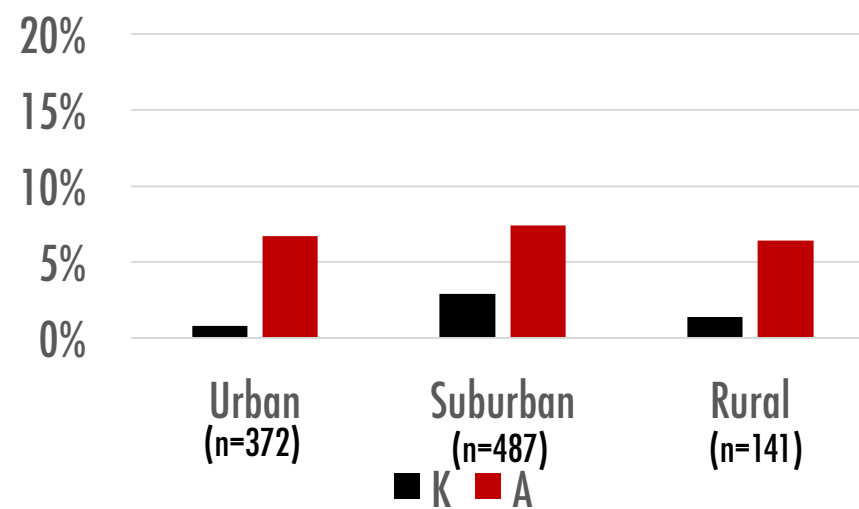
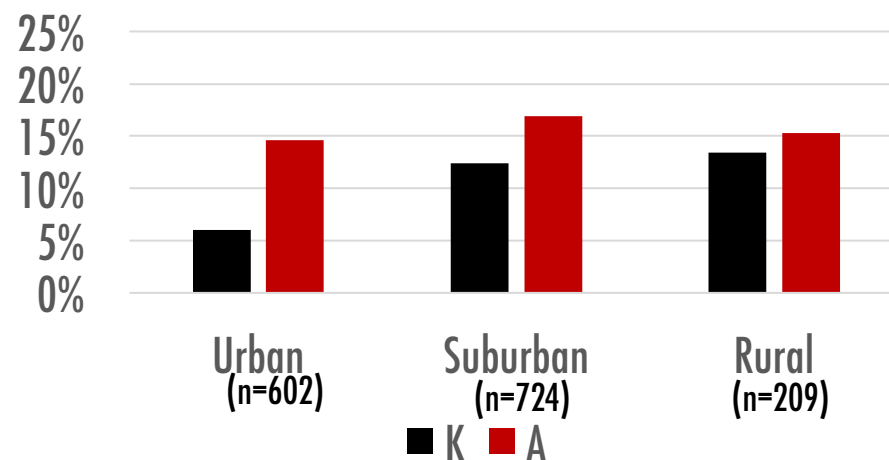
DESCRIPTIVE ANALYSIS

LOCATION CHARACTERISTICS

LOCATION



LAND USE



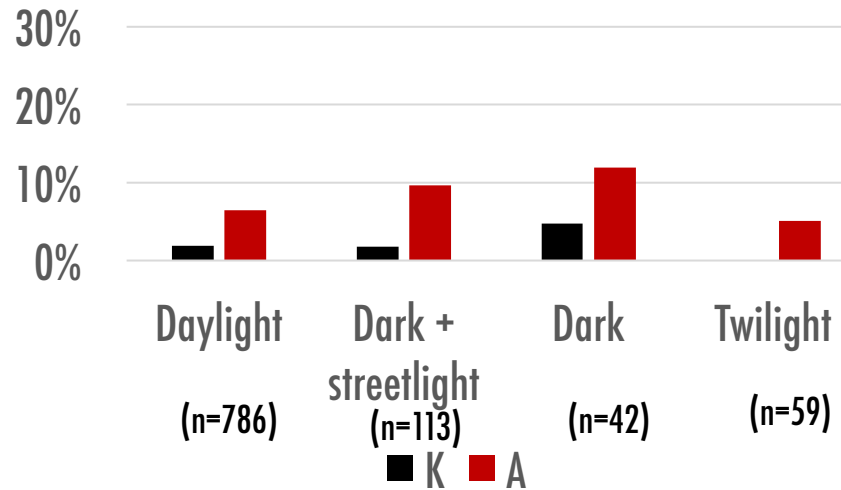
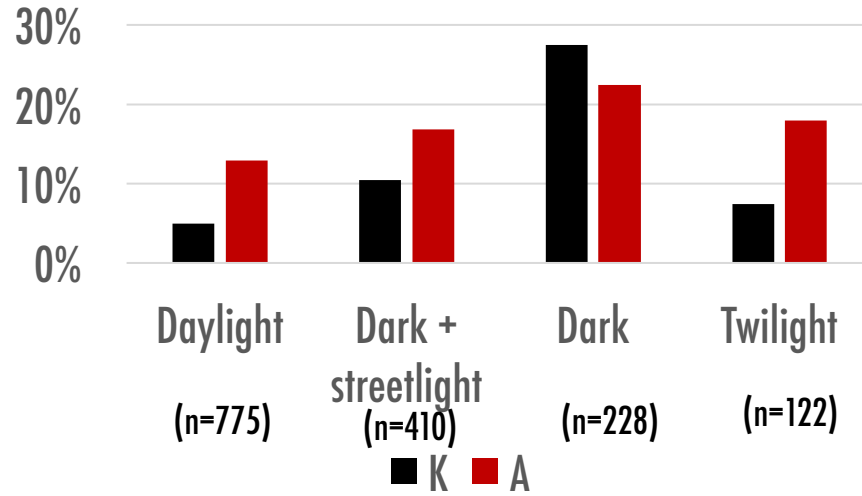
PEDESTRIAN

BICYCLIST

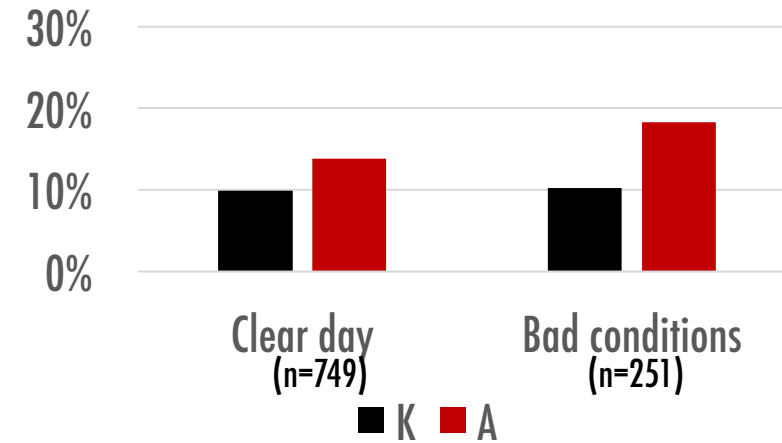
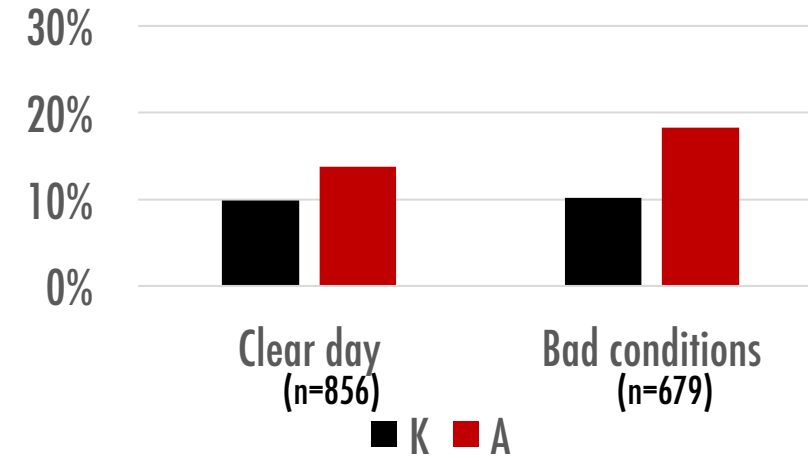
DESCRIPTIVE ANALYSIS

ENVIRONMENTAL CONDITIONS

LIGHT CONDITIONS



WEATHER



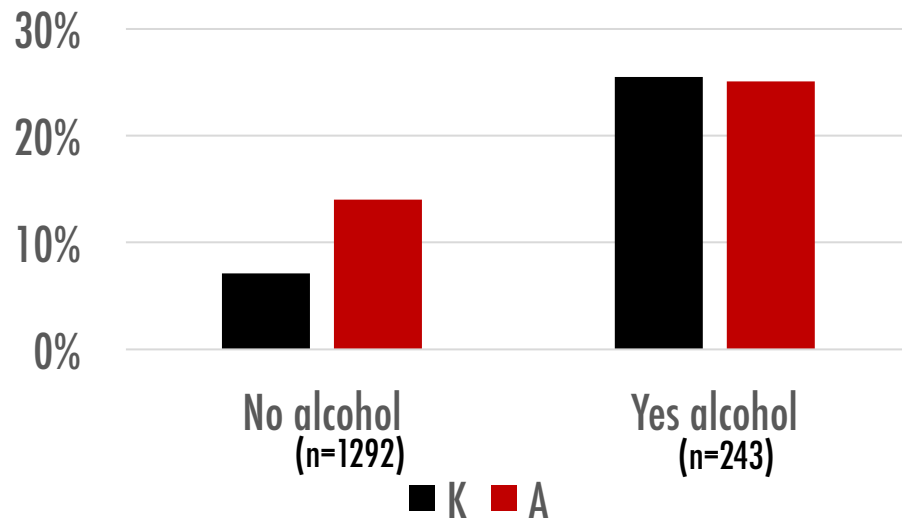
PEDESTRIAN

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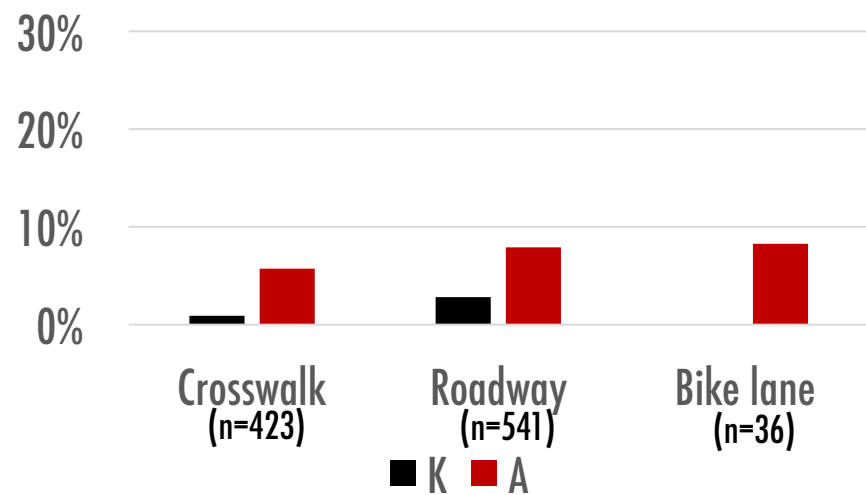
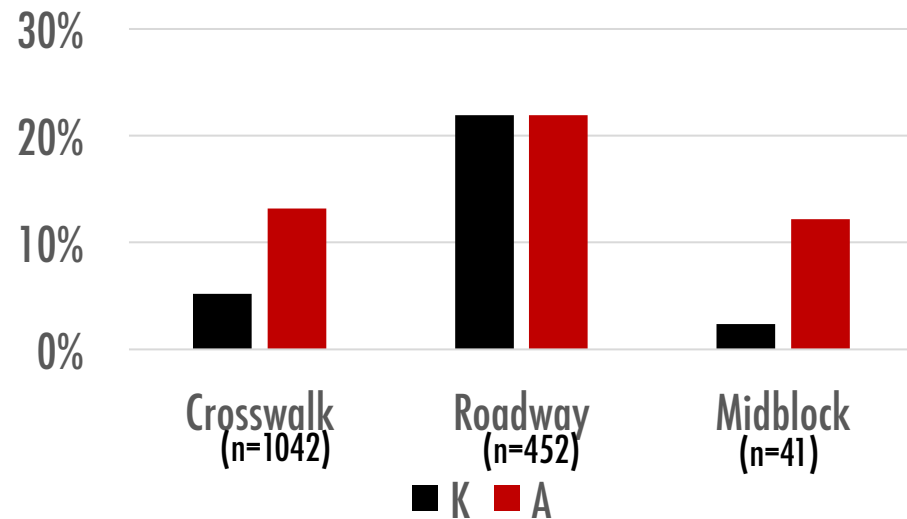
DESCRIPTIVE ANALYSIS

CRASH CHARACTERISTICS

ALCOHOL INTOXICATION



USER LOCATION



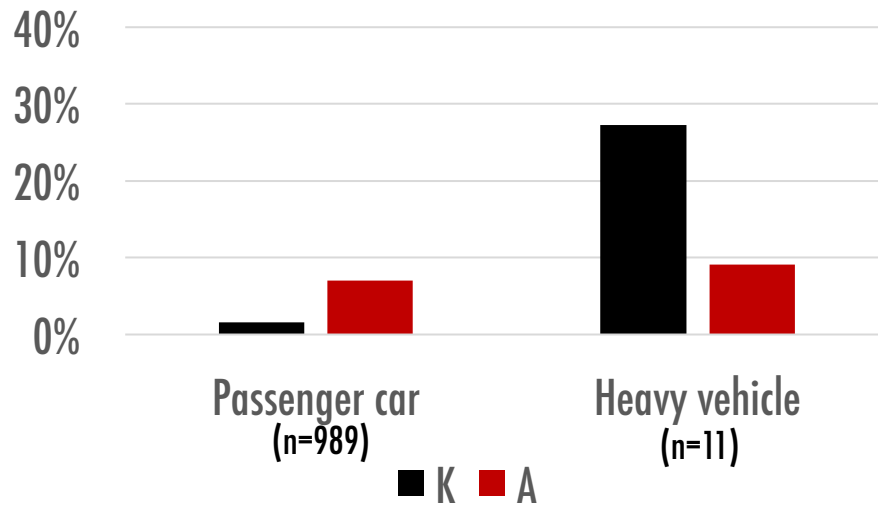
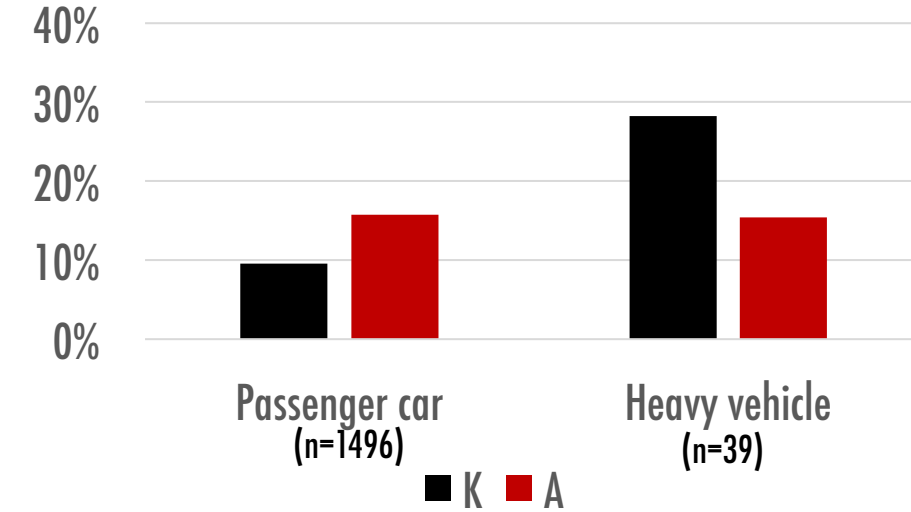
PEDESTRIAN

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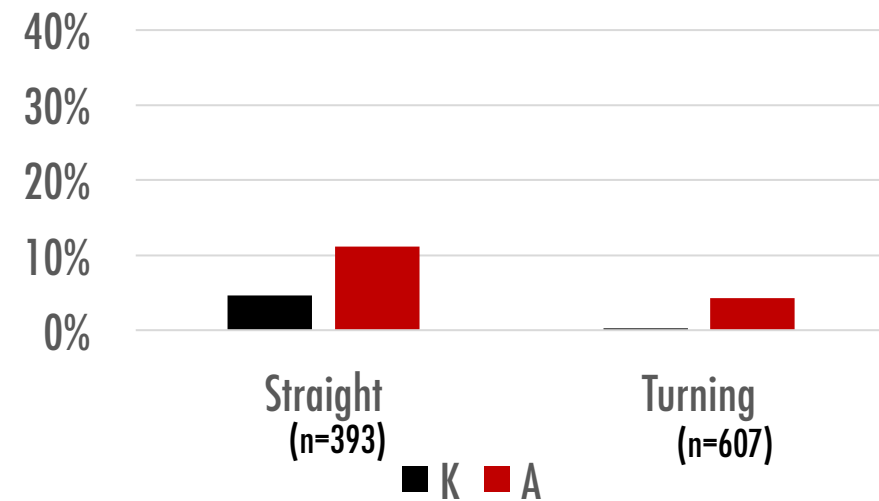
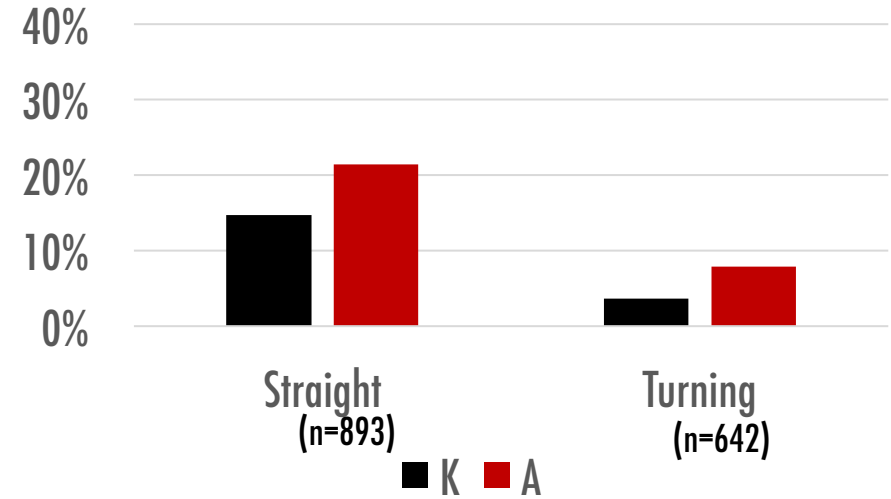
DESCRIPTIVE ANALYSIS

CRASH CHARACTERISTICS

VEHICLE TYPE



VEHICLE MOVEMENT



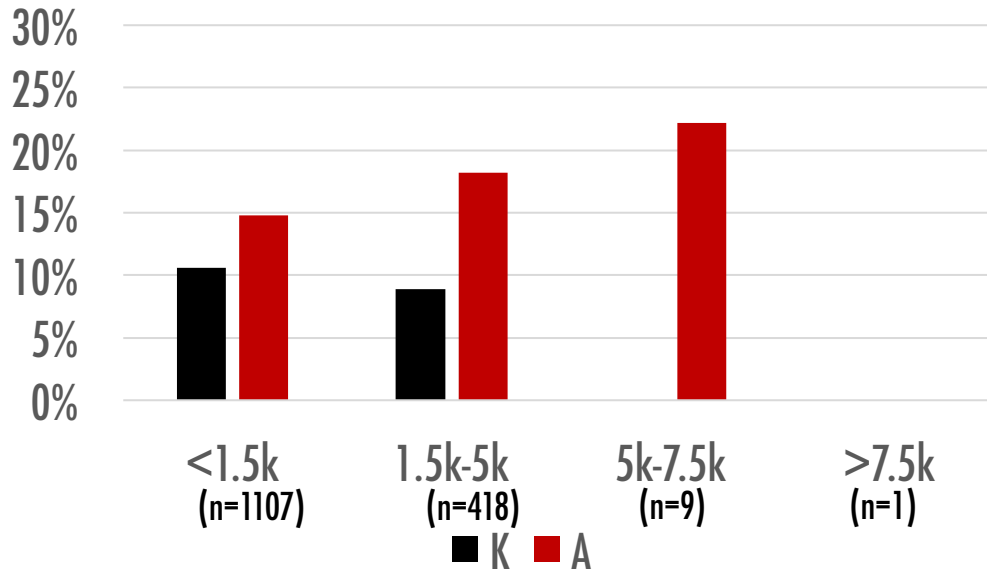
PEDESTRIAN

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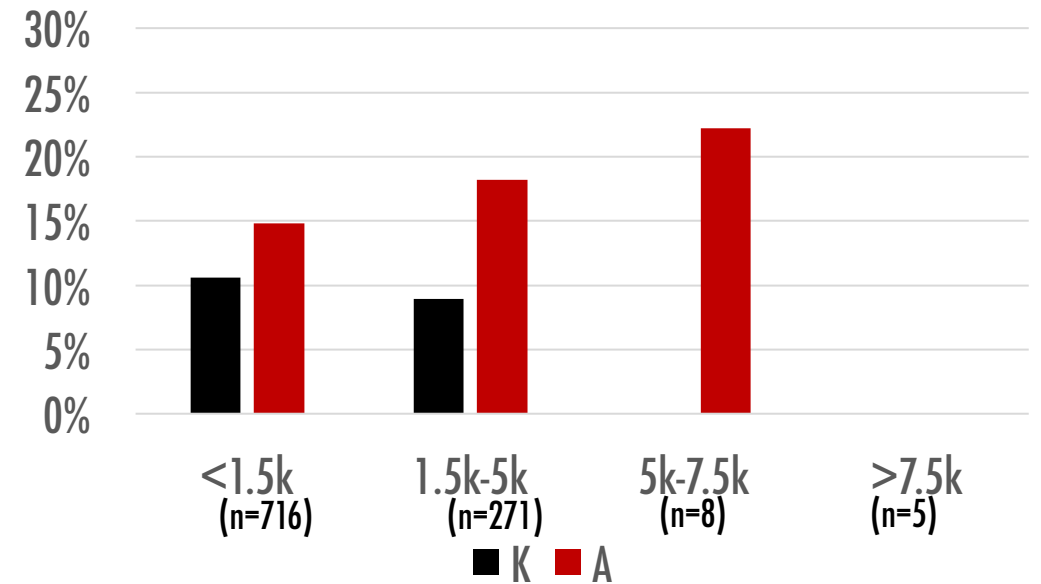
DESCRIPTIVE ANALYSIS

TRAFFIC CONDITIONS

AADT (ONLY TRUCKS)



PEDESTRIAN

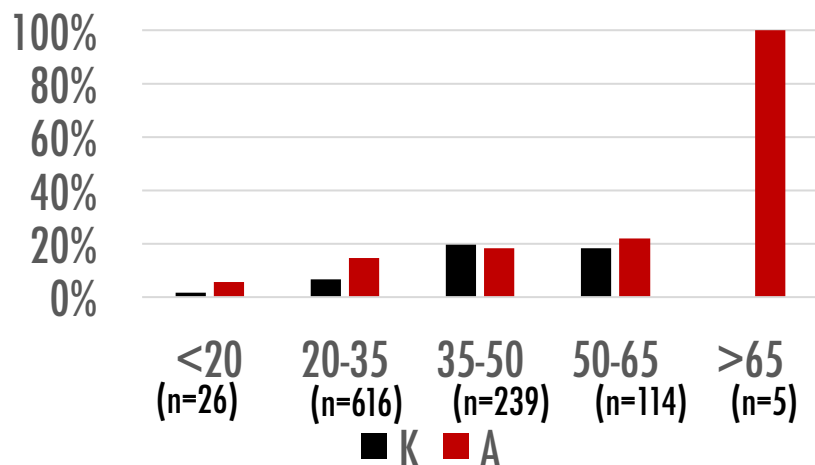
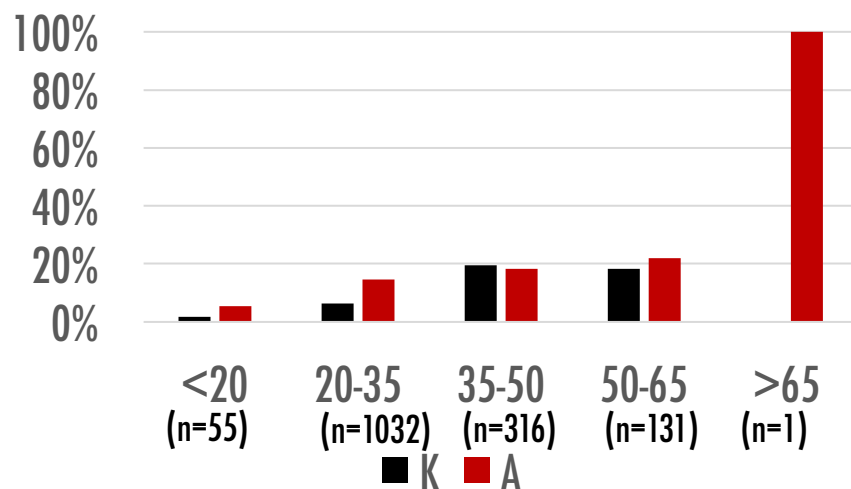


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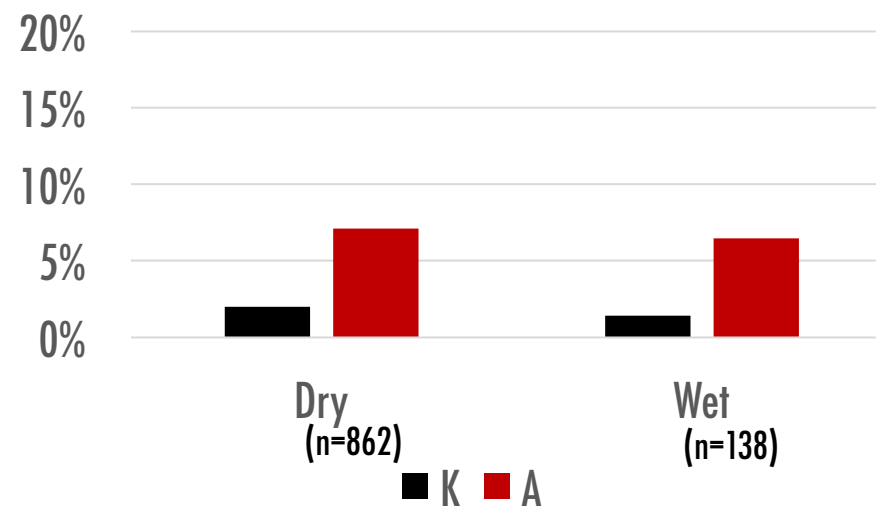
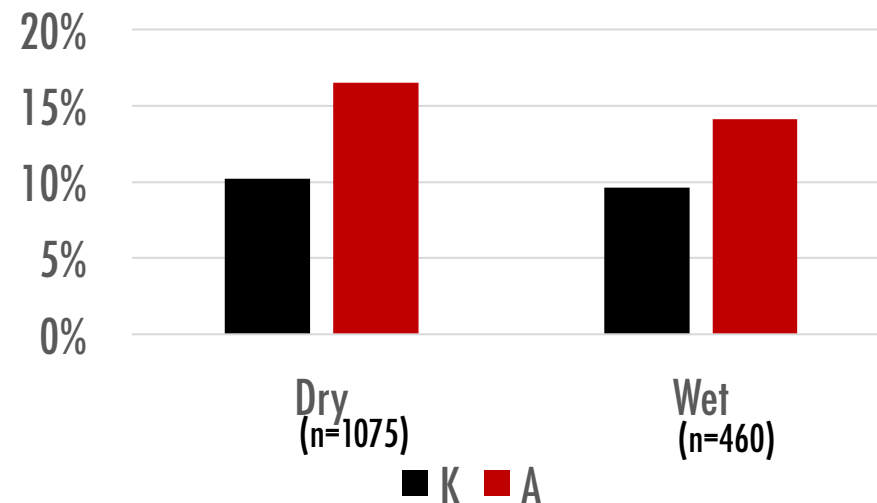
DESCRIPTIVE ANALYSIS

ROAD CHARACTERISTICS

POSTED SPEED LIMIT



ROAD SURFACE



PEDESTRIAN

BICYCLIST

DESCRIPTIVE ANALYSIS

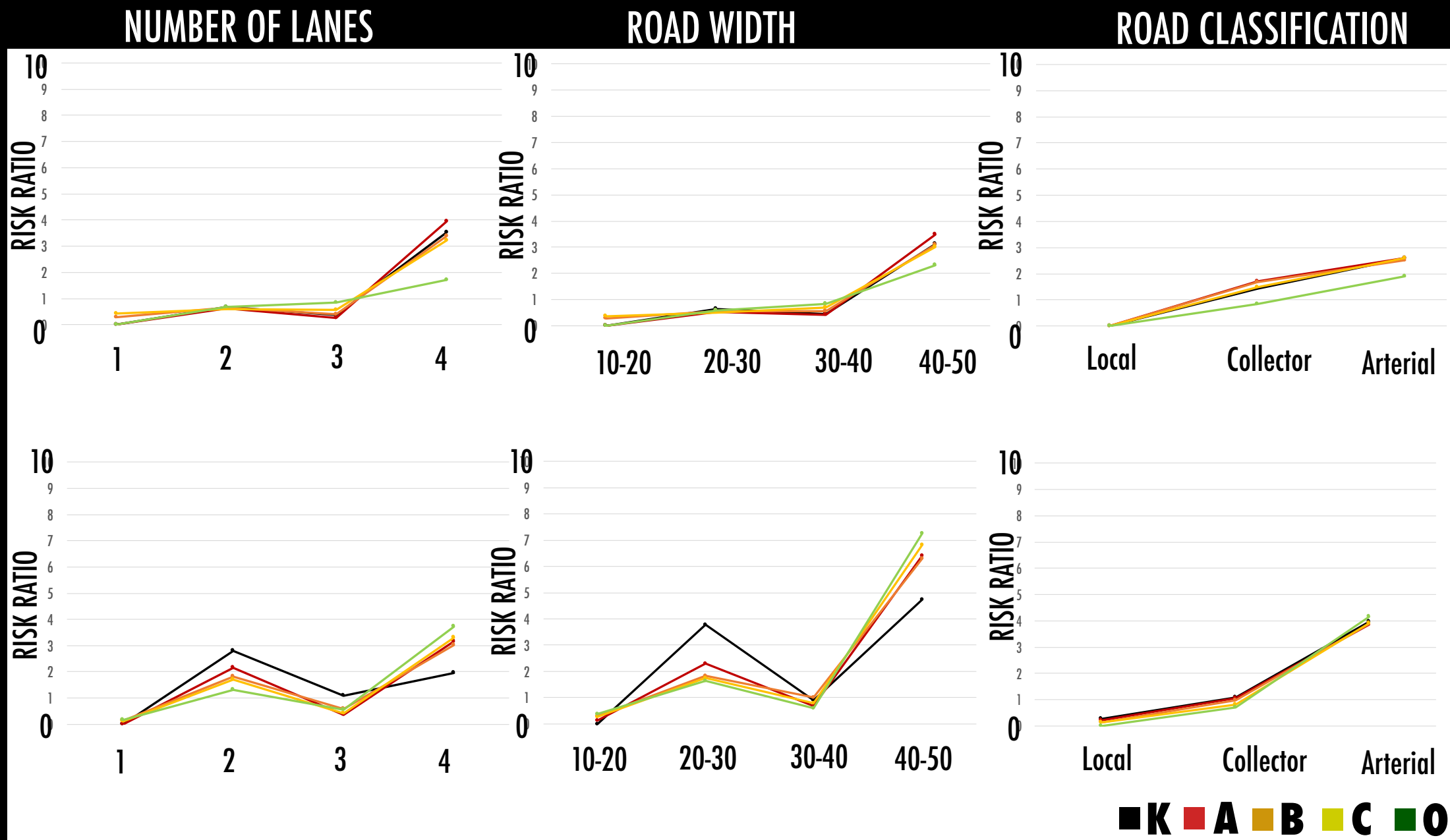
ROAD CHARACTERISTICS – EXPOSURE ANALYSIS

- Crash risk under various road characteristics
- Likelihood of crash involvement
- Depends on exposure
- Risk ratio \sim concentration of crashes (number of lanes, road width, and road classification)
- Exposure controlled by estimating the proportion of VMT

$$\text{Example: Risk ratio} = \frac{\text{Percentage of crashes in roads with 1 lane}}{\text{Percentage of VMT in roads with 1 lane}}$$

DESCRIPTIVE ANALYSIS

EXPOSURE ANALYSIS - ROAD CHARAC.





PEDESTRIAN

BICYCLIST



RESULTS

1. METHODOLOGY
2. INDIVIDUAL MODEL
3. POOLED MODELS
4. SENSITIVITY ANALYSIS



POOLED MODELS

CATEGORY	VARIABLE	EFFECT ON CRASH SEVERITY	
			
Socio-demographic	Older users	↑	N/A
Crash charact.	Alcohol involvement	↑	N/A
	Truck or bus involved	↑	N/A
	Crash location: Segment of the road	N/A	↑
	User location: roadway	↑	N/A
	Veh. movement: straight	↑	↑
Road characteristics	Posted speed limit >50 mph	↑	N/A
	Road classification: Arterial	↑	N/A
	Dark lighting conditions	↑	N/A
Traffic conditions	AADT > 10.000	N/A	↓
	AADT (only trucks) > 700	↑	N/A

POOLED MODELS

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	Dark lighting conditions	↑	N/A
Traffic conditions	AADT > 10.000	N/A	↓
	AADT (only trucks) > 700	↑	N/A

POOLED MODELS

Other significant variables:

- **Land use**
- **Segment vs Inters.**
- **Time of the day**

CATEGORY	VARIABLE	EFFECT ON CRASH SEVERITY	
			
Socio-demographic	Older users	↑	N/A
Crash charact.	Alcohol involvement	↑	N/A
	Truck or bus involved	↑	N/A
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	Dark lighting conditions	↑	N/A
Traffic conditions	AADT > 10.000	N/A	↓
	AADT (only trucks) > 700	↑	N/A

POOLED MODELS

Only road and traffic characteristics

VARIABLE

LEVELS

ODDS RATIO [95%CI]



Light conditions

Darkness - No streetlighting ↑

Road classification

Arterial ↑

Posted speed limit

>50 mph ↑

Location

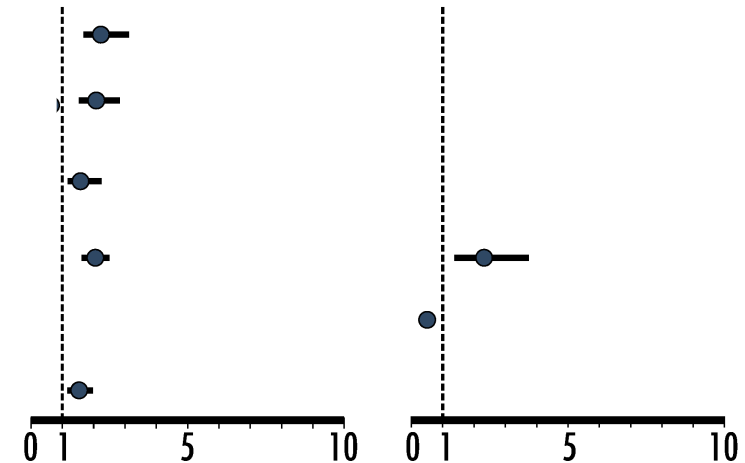
Segment of the road ↑

AADT

>10.000 ↓

AADT (only truck)

>700 ↑



POOLED MODELS

Only road and traffic characteristics

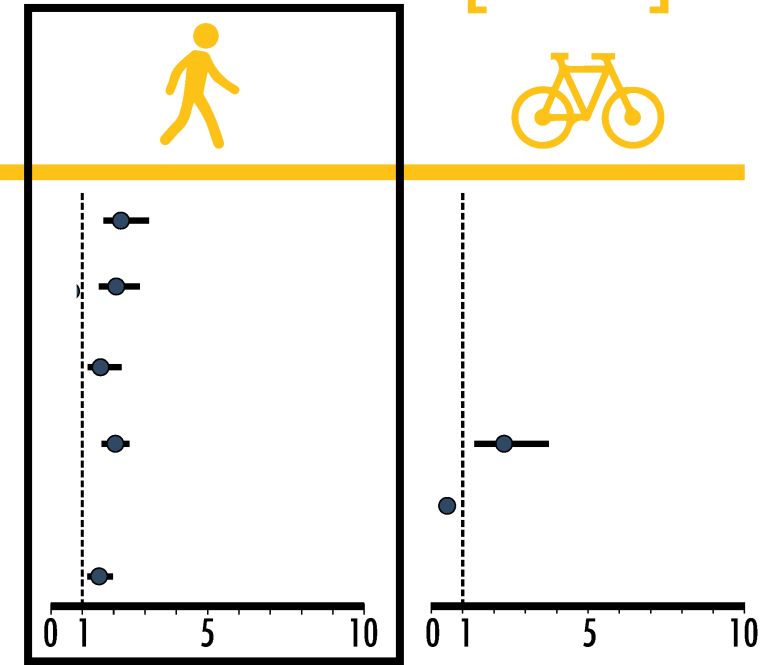
VARIABLE

LEVELS

ODDS RATIO [95%CI]

Light conditions
Road classification
Posted speed limit
Location
AADT
AADT (only truck)

Darkness - No streetlighting ↑
Arterial ↑
>50 mph ↑
Segment of the road ↑
>10.000 ↓
>700 ↑



POOLED MODELS

Only road and traffic characteristics

VARIABLE

LEVELS

ODDS RATIO [95%CI]



Light conditions

Darkness - No streetlighting ↑

Road classification

Arterial ↑

Posted speed limit

>50 mph ↑

Location

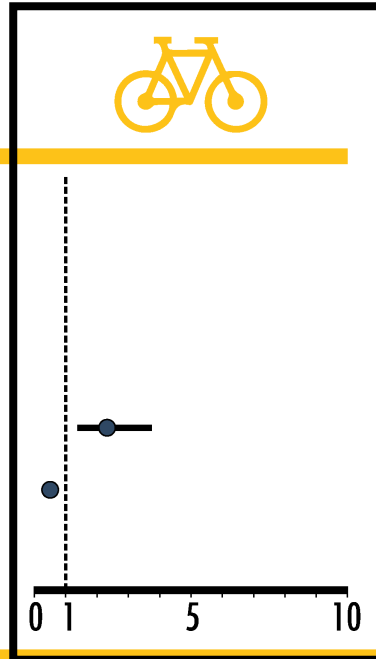
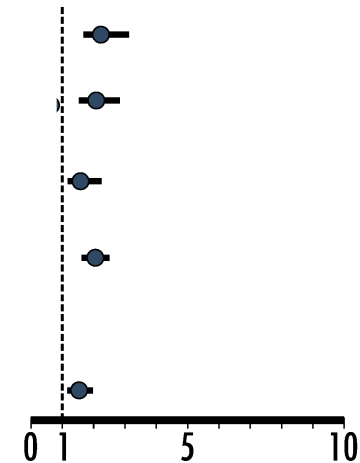
Segment of the road ↑

AADT

>10.000 ↓

AADT (only truck)

>700 ↑



SENSITIVITY ANALYSIS

PEDESTRIAN MODEL

CRASH SEVERITY ~ Light conditions +
Road classification +
Posted speed limit +
Pedestrian location +
AADT(Only truck)

SENSITIVITY ANALYSIS

PEDESTRIAN MODEL
BASELINE SCENARIO

CRASH SEVERITY ~

Light conditions (**DAYLIGHT**) +
Road classification (**LOCAL STREET**) +
Posted speed limit (**<50 MPH**) +
Pedestrian location (**CROSSWALK**) +
AADT(Only truck) (**<700**)

Prob. (K+A)=7.4%

SENSITIVITY ANALYSIS

PEDESTRIAN MODEL

BAD LIGHTING SCENARIO VS BASELINE SCENARIO

CRASH SEVERITY ~

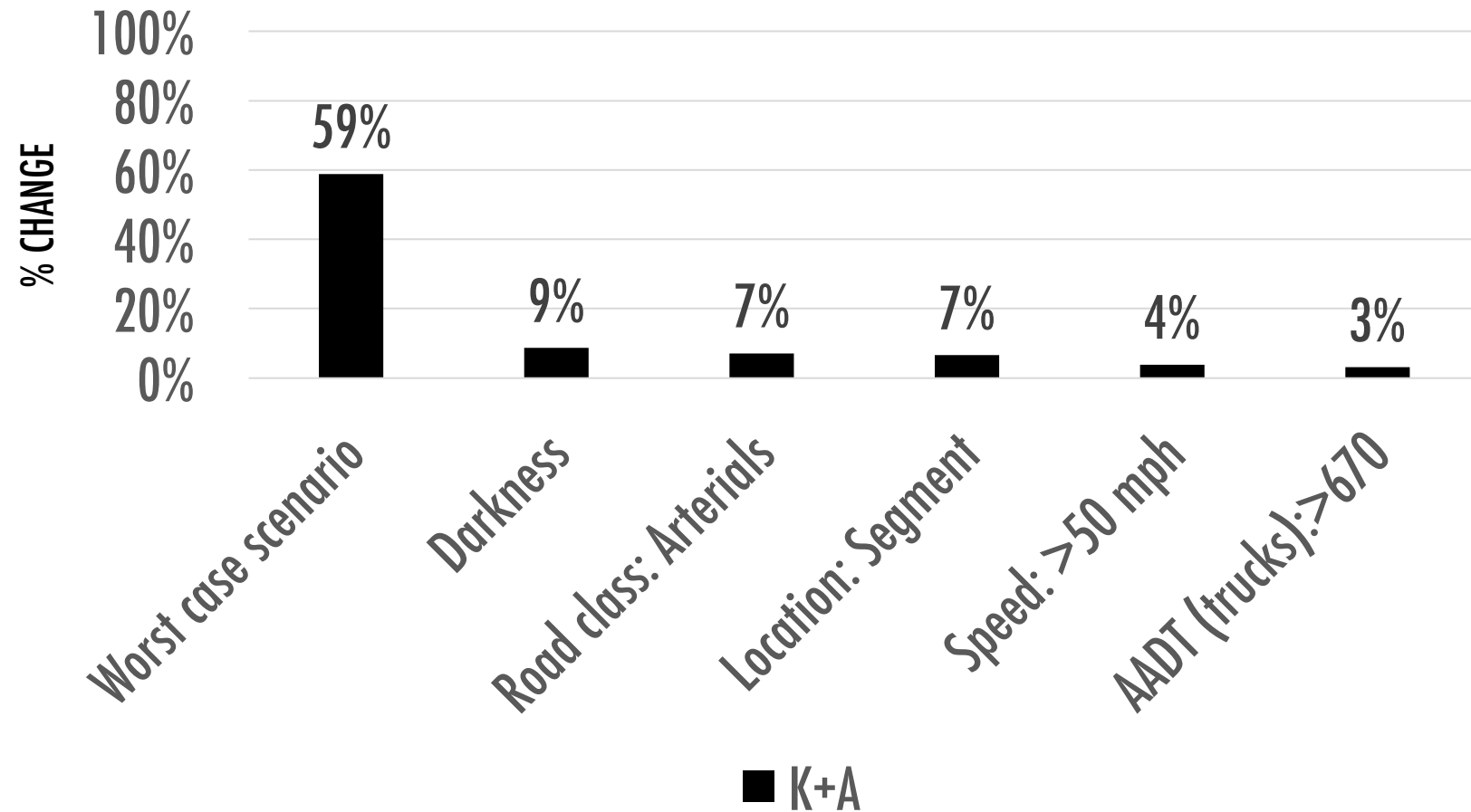
Light conditions (**DARKNESS**) +
Road classification (**LOCAL STREET**) +
Posted speed limit (**<50 MPH**) +
Pedestrian location (**CROSSWALK**) +
AADT(Only truck) (**<700**)

Prob. (K+A)=7.4%

Prob. (K+A)=16.1% ↑ *Change = +8.6%*

SENSITIVITY ANALYSIS

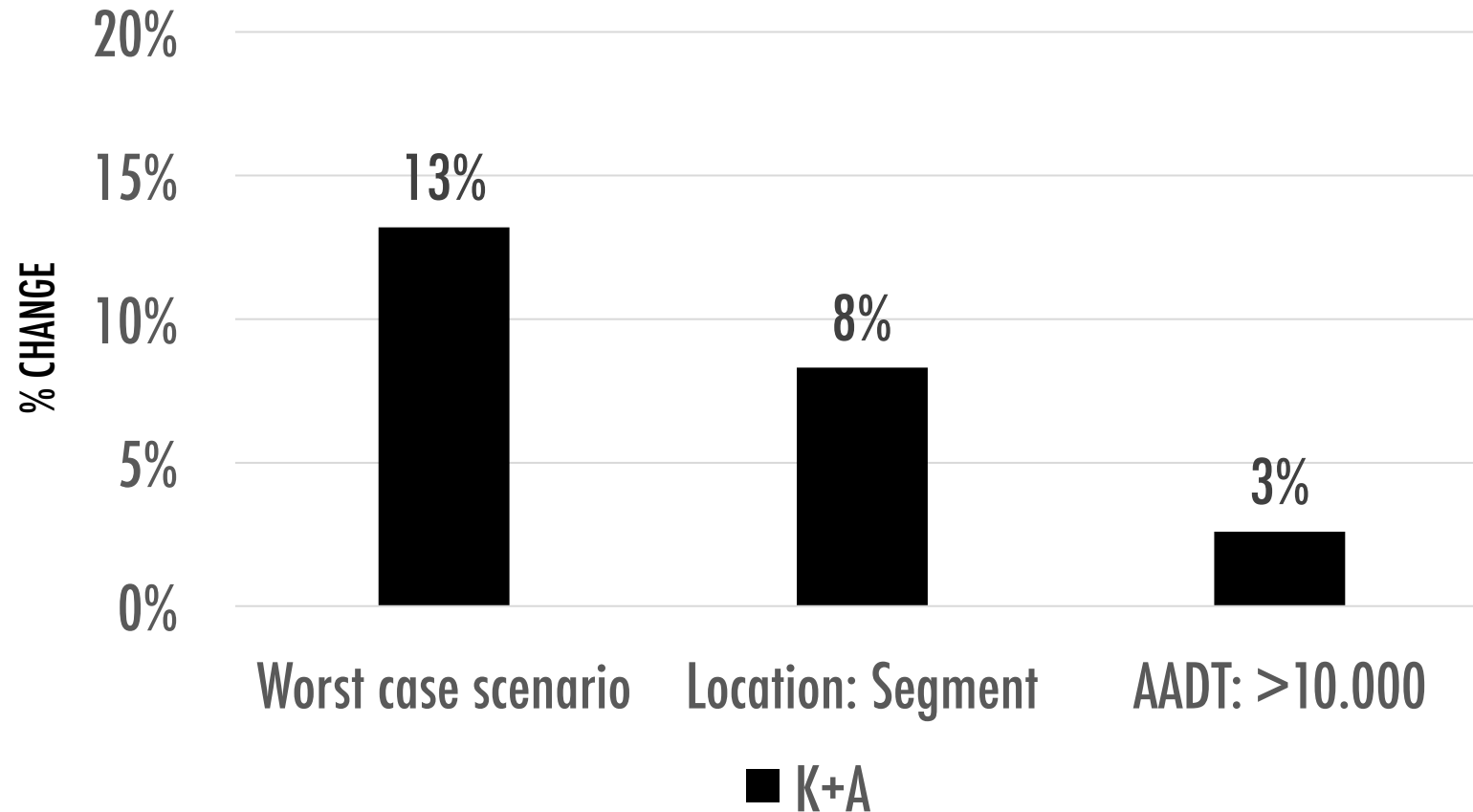
PEDESTRIAN MODEL



SENSITIVITY ANALYSIS

BICYCLIST MODEL

CRASH SEVERITY ~ Bicyclist location+
AADT



CONCLUSIONS

1. TAKEAWAYS

- Age
- Alcohol intoxication
- Vehicle size
- Vehicle movement
- Posted speed limit
- Light conditions
- Road classification
- Road surface
- Location of the user
- Land use and AADT

CONCLUSIONS

2. MITIGATION

- Educational campaigns
- Training courses
- More strict enforcement
- Protection vulnerable users

CONCLUSIONS

3. LIMITATIONS and FUTURE RESEARCH

- Underreporting
- Speed
- Bike facilities
- Special pedestrian signals

QUESTIONS?

ACKNOWLEDGMENTS

DISSERTATION COMMITTEE:

- Miguel Figliozi
- Chris Monsere
- Avinash Unnikrishnan

TTP LAB

Transportation engineering
and planning
Master students